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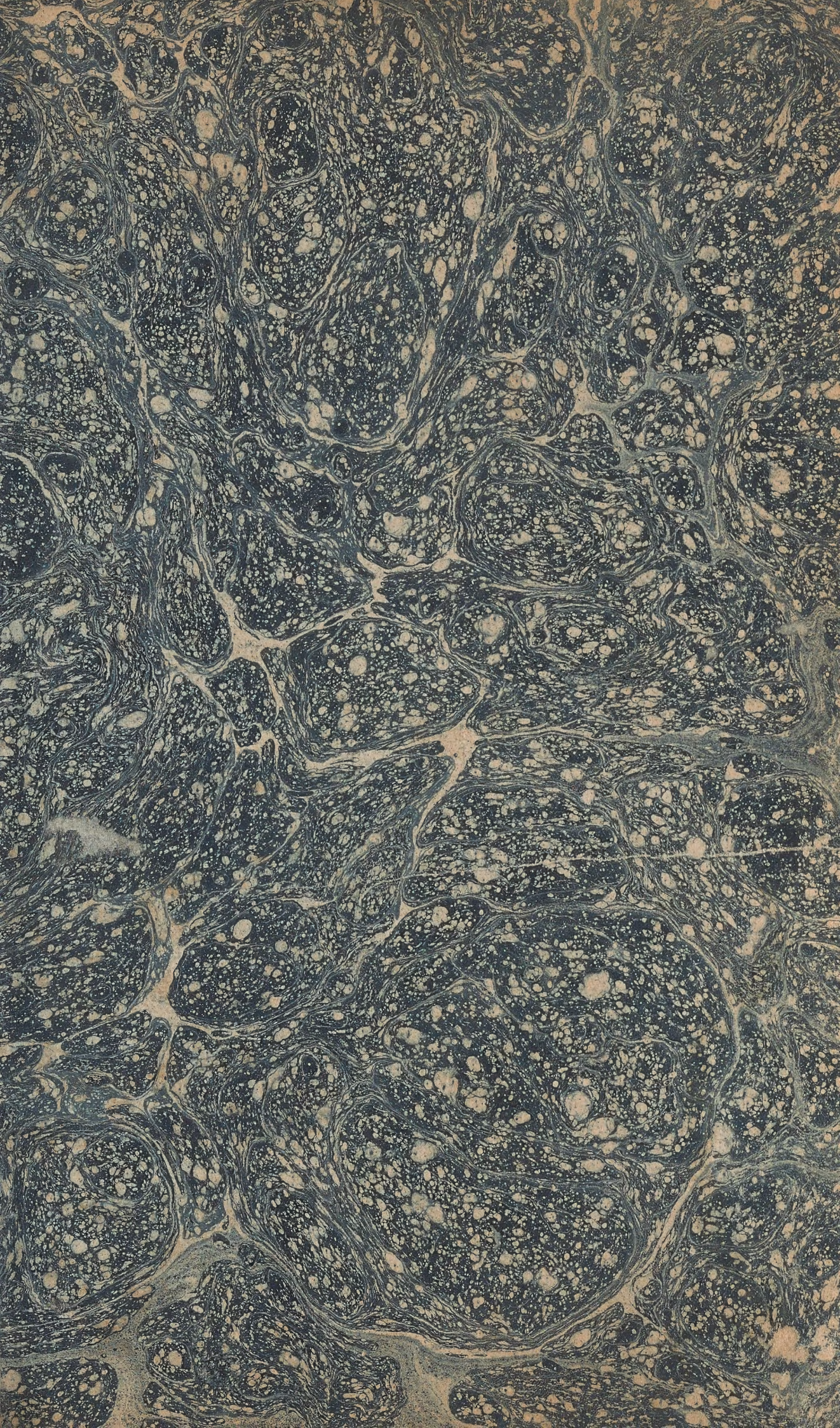

Orig. MS. Leycester (Robert, of Toft Hall, Knutsford)

I, Electricity, ff. 102, with 6 drawings

II, Magnetism, ff. 22, with 4 drawings. c. 1800

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Robt. Leycester

Electricity.

1. It was observed by some Philosophers several hundred years before the Christian era, that amber acquired, by being rubbed, the surprising property of attracting and then repelling light bodies. No advances however were made towards the discovery of the cause of this till about the commencement of the 17th Century, when it was found that glass and many other substances as well as amber, had the same property when rubbed. It was also soon found that these substances, when rubbed to a greater degree, became luminous in the dark

The attention of Philosophers began now to be excited to the subject of Electricity (a name which it has acquired from ηλεκτρον, the Greek word for amber) and it was discovered that these sub-stances not only shone in the dark, by rubbing, but they made also a crack-ling noise, emitted streams & sparkes, seemingly of fire, which struck a persons knuckles or any object presen-ted to them, & that they gave out a peculiar smell, something like that of sulphur. Some years after this it was discovered that the property might be made to pass suddenly thro' the limbs of animals, giving them a violent & painful shock

2. To account for these astonishing ap-pearances, ingenious men have for-med various conjectures. It is now however, generally agreed that these appearances are occasioned by a fluid,

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sui generis, which is diffused thro' all material substances. Each substance has a certain portion of this fluid allotted to it by the Creator, and that portion may be called its natural share. By various means however, chiefly by rubbing, a body may acquire more of this fluid than its natural share, or may be deprived of some of its natural quantity. Now in either of these cases that body will shew signs of electricity. If, for instance, I take a long & thick tube of glass & rub it with flannel, it will attract a feather or any light substance that is brought near it. And the reason of this is, that the glass now possesses more of the electric fluid than its natural share, having by fiction, received some from the flannel. Portions of this fluid residing in different bodies are supposed to repel each other, but the fluid

strongly attracts all material sub-
stances. Now while the feather and
the tube possess each its natural share,
all is quiet, for tho' the natural elec-
tricity of the tube attracts the feather
placed near it, the feather cannot
obey this attraction, for the two por-
tions of electricity in the tube & fea-
ther repel each other, and prevent
their approach. But let the tube
be possessed of more than its natural
share of electricity, and then they
will approach. The natural share
of fluid in the feather is now no
match for the superior repulsion
of the plus quantity of electricity
in the tube, but is driven back by it
to the remoter parts of the feather,
& the feather itself obeys the attrac-
tion of the fluid in the tube.

The feather now touches the tube & receives from it some of its superabundant electricity, and so much as to make them both equally filled. As soon as this is effected, the feather is repelled by the tube, for the mutual repulsion of the two fluid quantities of fluid is an over match for the attractions which would keep them together. And the feather continues to be repelled by the tube till it touches some substance to which it can give its superabundant electricity. When it has done this, it is attracted and repelled by the tube as before. When a stick of sulphur or wax is rubbed with the flannel, it is found to lose some of its natural share, & in this minus state it attracts the feather. The defective quantity of fluid in the resinous

yields to the superior repulsion of the fresh wax on the feather, and the sulphur obeys the attraction of the electricity on the feather and they approach, that is the feather to the sulphur, because it is far lighter and free to move. The feather soon loses some of its natural charge to the sulphur, and they both become nearly neutral. The feather is now repelled, & this brings a considerable difficulty before this beautiful, and in other respects, very satisfactory theory. Mr. Franklin, who first suggested the theory, acknowledges it to be a difficulty he is not able to solve. That glass and wax, when rubbed, are actually in different & opposite states of electricity there can be no doubt, for a feather repelled by the glass is attracted by the sulphur, & what the sulphur repels, the glass attracts.

These circumstances suggested our hypothesis, which for some time was received, before Mr. Franklin proposed his theory. It supposed, there are two distinct electric fluids, the vitreous, or vitrial or Glass, and substances of that kind, and the resinous found in Sulphur, resins &c. Now it is obvious that upon this hypothesis, there is no difficulty in the cases above mentioned, the repulsion of the feathers from the sulphur, and this circumstance with a few others has led some, even lately, almost to prefer the hypothesis of the two fluids. The Franklinian theory, however is so strongly recommended by its beautiful simplicity, by the very complete manner in which it explains electrical phenomena in general, & by the great light which it throws on the whole subject, that it ought not to be rejected on account of one or two diffi-

=culties, which considering that the subject is new, further discoveries may be expected to remove.

4. Glass, Sulphur &c. when made electrical, by rubbing, are said to be excited. But there is a considerable class of substances in which these appearances cannot be excited, metals of all sorts, for instance. The former class of substances are called electrics, these latter, non electrics. But non electrics, tho' they cannot be excited, may yet be made to exhibit all the appearances of excited electrics. A piece of metal standing entirely upon Glass, and brought to one excited electric, will receive the fluid from the electric, and shew all these phenomena. It will attract and repel light bodies, the same sensible steam exceeds from it, and it gives sparks

to every body approaching it. It differs, however, from an excited electric in this remarkable circumstance, that it loses once it has given a spark to an approaching body, all electric appearances cease, whereas you may take any number of sparks from the electric before the excitation is destroyed. From these circumstances it is manifest that the electric fluid cannot pass thro' electrics, nor from one part to another in them, but that non electrics conduct the fluid to any other substance that may approach them with the greatest ease, so that if the metal above mentioned had not stood on glass, or some other electric, it would not be possible for it in any degree to have retained the fluid. A Metal, or other non electric, when separated from all other non electrics,

is said to be insulated. And from the circumstance, here stated, all non electrics are called conductors, and electrics non conductors. In conductors there is found a gradation, Metals are the best, and after these rank Charcoal, the fluids (except air and Oil) and a vacuum. Of non conductors, Glass and precious stones seem the best, & after these follow Amber, Wax, Sulphur, Silk, Air, Baked wood &c. Many conjectures have been formed respecting the circumstances which make some substances conductors and others non conductors. There are many substances which, in the common temperature, are non-conductors, which will conduct the fluid when made hot. This circumstance seems to shew that the

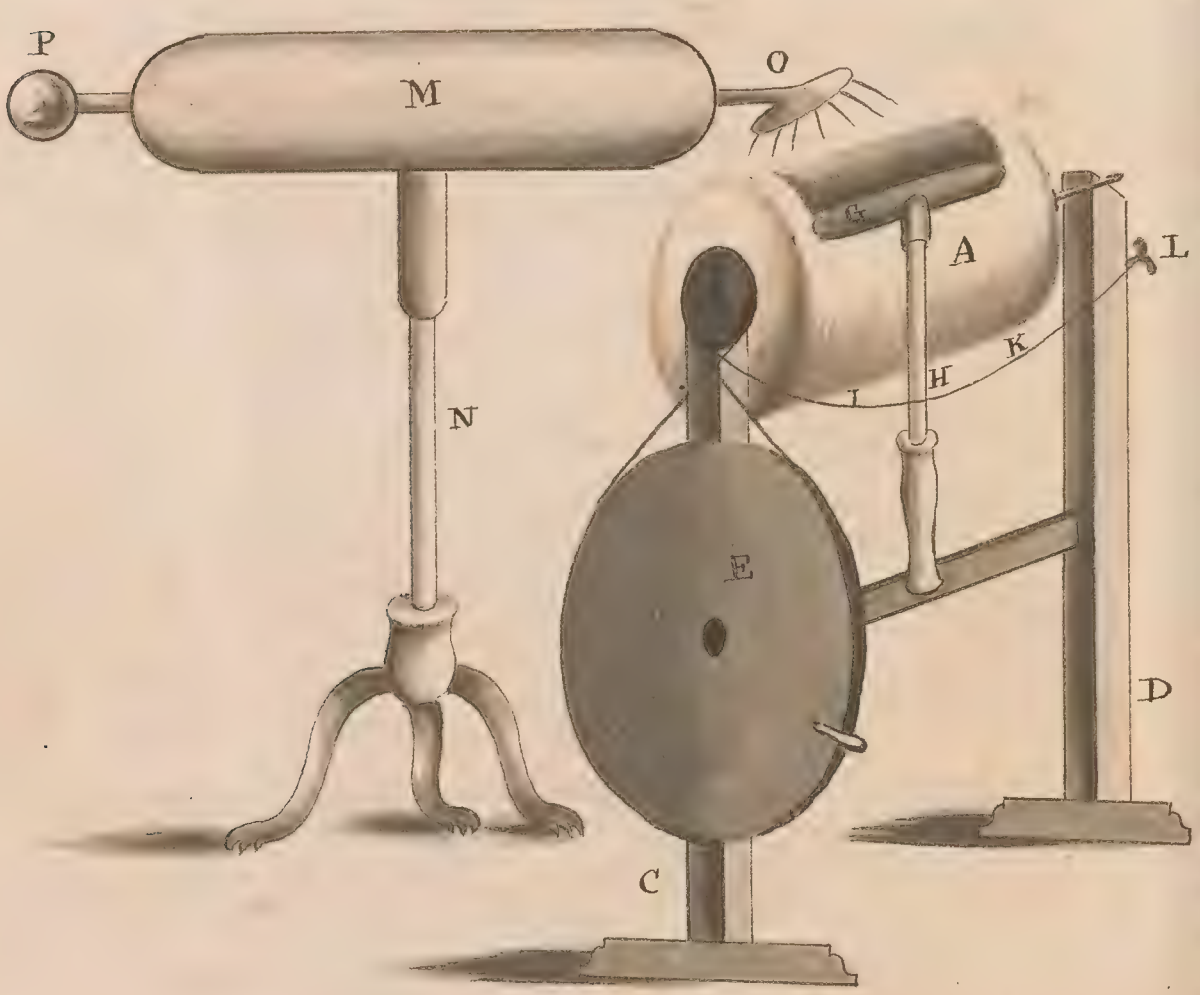
property of conducting depends on a particular temperature in each body.

5. As it would be extremely tedious to procure a sufficient quantity of electricity for most experiments by working a rubber on an electric with the hand, Machines of various construction have been invented. The great principle in all these machines is to make an electric revolve so as that its surface may be in contact with a rubber fixed to some part of the frame, and connected with the ground by proper conductors. In this way a very considerable excitation is procured in a short time and with a small degree of labour. If the electric be such as to become filus by excitation as glass for instance, then the

rubber imparts the surplus quantity from itself, the bodies immediately connected with it and from the earth, and where the electric becomes minus by excitation, its natural electricity is conveyed to the surrounding bodies and the ground. That this is the case may be proved by insulating the rubber. When you do this, the excitation is very small, and it is constantly found that the electric and rubber are in the opposite states. Where the electric is glass, the rubber is negative, having given its natural share to the glass. It is manifest from this, that where a copious excitation is required, care should be taken that there be a good communication between the rubber and the ground. To secure this, Dr. Franklin, in dry weather often fastened a wire from the rubber to the bars-

-dle of a water furnace. A copious ex-
-citation being procured by this part
of our electrical machine, the other part
of it consists of a communicant insulated con-
-ductor, from one end of which a few wire-
-like stand prominent. This end is
brought near to the electric, and the
points receive the fluid from it.
The following figure will shew the parts
of a machine put together, and make
the above description perfectly understood:
A is a glass cylinder mounted upon
the frame CD, and moved upon its
axis by a cord round the two wheels E
& F; G is the rubber fastened to the pil-
-lar H, which stands on a slide going
into the binder of the frame, front of the
pillar is of glass that the rubber may be
occasionally insulated; I K is a cord pass-
-ing from one part of the frame to the other
round the pillar H and which by moving

the screw L makes the rubber press harder or lighter upon the cylinder. M, N, O, P, is the positive conductor. M is a cylinder of tin, O a projection presenting the points of needles to the excited cylinder to receive the electric fluid from it, P a brass ball for the



convenience of taking sparks from the

conductor, and of experiments in general,
N is a glass pillar to insulate and support
the conductor M.

6 In order to increase the excitation, the
surface of the rubber is covered an amalgam.
Various metalic mixtures have been
used for this purpose, but the best is one
recommended by Baron Kienmayer
of Vienna; it consists of one part of zinc-
ified Zinc, one of Tin, and two of Mer-
cury. The Zinc and Tin are melted in
an iron ladle, and the mercury added
to them as soon as they are taken off
the fire: the mixture must be stirred
with an iron spatula, and when cold,
reduced to a very fine powder in a glass
or wooden mortar. Some Damar being
laid on silk, this powder is strewed
on it, by means of a fine sieve, and when

dry, that which adheres is solicited by rubbing it with a steel burnisher, after which a drop of sweet oil is laid on its surface. Mr Cuthbertson, a very celebrated amalgamator, in using this amalgam, finds it more advantageous to mix it up with lard to the consistence of an unguent, which must be spread on the surface very thin and smooth. Besides this preparation of the rubber, it is usual to sew a piece of thin silk to the side of it so that it may follow the rubber, and extend over the cylinder also as far as the points of the prime conductor. The use of this is to prevent the fluid flying back in sparks to the negative rubber, or being dispersed into the air, and where greasy matter is used with the amalgam, in order to keep the silk free from it many find the unguentum upon another rubber,

which they hold to the cylinder by the hand, removing the silk while the cylinder is excited in contact with the amalgam. In a few turns a copious excitation is produced, the amalgam is then removed and the silk passed over the fixed rubber is applied to the cylinder. Upon working the machine now, the excitation is continued and even increased.

7. A variety of amusing experiments are often made with the electrified Leyden conductor to shew that even electrics, when electrified, will exhibit all the phenomena of excited electrics. For instance the cork of cotton attracted and repulled, the bran, the dancing figures, the bells, the melted sealing wax drawn into threads &c. A stronger illustration may now also be seen of the opposite states of Electricity

ies bodies, by bringing an insulated con-
-ductor, connected with the rubber, near to
the prime conductor. Upon working the
machine one conductor strongly repels
whilst the other attracts, and when the
conductors approach, a spark passes
between them evidently much stronger
than if the second conductor had been
in no electrical state at all. By in-
-sulating the rubber also, and mak-
-ing the prime conductor communi-
-cated you are able by working the ma-
-chine to shew an high degree of the
negative state in the rubber, or any in-
-sulated conductor connected with it.
The human body may be made part
of the prime conductor by a person's
standing on a stool with glass feet,
or being in any other way insulated

and connected with the positive conductor. A person thus electrified will attract light bodies, give sparks &c. The pulse is also in these circumstances quickened, and perspiration promoted.

8. Much has been said by writers on Electricity about Electrical Atmospheres. By these are meant those spheres of action which surround all excited or electrified bodies. The hand experiences a peculiar sensation upon being brought within them, and feels as if it were touching a cob-web. From this circumstance probably, and from the opinion formerly held, that the charge resided here, the term Atmosphere came to be applied to these spheres of action. With regard to these

atmosphere it is an established and im-
portant principle in electricity, that
bodies brought into the atmosphere of
electrified bodies, acquire the state of
electricity opposite to that of the electri-
fied bodies. This may be proved in the
usual way by a cork ball, but it is
beautifully illustrated and established
by the following experiment. Suspend
two cork balls on threads of linen from
the prime conductor, upon working
the machine they are electrified and
diverge with positive electricity; while
they are in this state bring an exci-
ted tube of glass under them, and
so near that they may be in the at-
mosphere of the tube, the atmosphere
repels the electricity from the balls to
the threads, and they begin to converge,

as the tube is gradually brought nearer, all the plus electricity is driven from the balls and they meet. The tube being brought nearer still, their natural share also is repelled from them and they diverge with negative electricity. If the tube now be removed gradually the balls converge, meet, and then diverge with the positive electricity they receive from the prime conductor as at first. If one end of an insulated conductor be brought into the atmosphere of the prime conductor, that end will be negative, the electric atmosphere repelling its natural share, and driving it towards the other end, this other end becomes therefore positive. Both the two ends of this conductor do then acquire the opposite states until

be manifest if you suspend a cork ball by a linen thread from each end of the conductor; for the excited tube will repel the ball hanging from the remote end, but attract the other. While this conductor is standing in these circumstances, if you take a spark from its remote end and then remove it the whole conductor will be found negative, because it has lost some of its natural share. This influence of electric atmosphere is explained from the principals mentioned S. 2. 2 when speaking of the attraction and repulsion of the feather by the excited tube.

If an insulated conductor be brought into the atmosphere of the prime con-

-ductor, as in the experiment just now related, and another insulated conductor to be brought near the remote end of this, so as to receive sparks from it and make it highly negative, and if the prime conductor be then discharged with one explosion, the fluid which the last conductor received, will suddenly return into the second conductor with a strong bright spark. This is called the returning stroke. It was discovered some years ago by the present Lord Stanhope, if two persons stand in the situation of those two conductors when the prime conductor is discharged, the first person will feel the returning stroke. If the remote person stand upon the floor

the returning stroke will be greater, because the insulated person in that case, will have been more negative. More will be said of the effects of the returning stroke, when we come to speak of natural Electricity.

10. The action of points upon electrified bodies is very remarkable, and is a circumstance which must be particularly attended to. When an uninsulated metalic point is presented to such bodies they silently and speedily discharge their electricity, and if a point stand perpendicular upon the prime conductor it cannot be charged, the point throwing off the fluid as fast as it is communicated. The action of points is the same whether the conductor be positive or negative and while the action or current of air

proceeds from there. The cause of this current has been thus explained. The minute portion of air upon the point must be in the same state of electricity with the point itself, and upon the principles that separate portions of electricity repel each other, this portion of air will be repelled from the point, and a fresh portion from the neighbourhood will instantly rush to the point, be immediately electrified and repelled, and these portions succeeding each other so very rapidly, they form the current which is observed. This explanation when applied to the negative point is certainly defective. That bodies in the negative state should repel bodies in the same state is a difficulty which has not as yet been explained. Points that are discharging or taking in electricity are

luminous in the dark, but there is this difference, from the former there issues a stream of light divided into denser streams at the extremities, this is called a brush, upon the latter, the light is more minutely divided and diffused equally, this is called a Star. With regard to the action of points in discharging electrified bodies, it is best accounted for thus. Any body brought into the atmosphere of the prime conductor is negative, and the plate of air between it and the conductor has its two surfaces in the opposite states, that connected with the prime conductor positive, and that contiguous to the other body negative. Now when the body presents to the conductor a blunt broad surface, the plate of air is wide and will take more electricity to charge it, that is to say,

it may be brought nearer to the conductor before the opposite sides of the plate of air be so very strongly positive and negative as that a communication will be forced between the positive and negative sides. When the surface presented is narrower the communications will be forced thro' a plate of air with a sparkle and must at a greater distance, and where the presented surface is reduced to a point, the discharge will take place at a distance, the discharges will be very frequent so that they may be considered as a constant stream of the fluid, and the sparkles so very small as not to be seen or heard.

11. If instead of the plate of air just now mentioned, any other electric, as glass for instance, be interposed between the two conductors, the atmosphere of that which is charged will extend its influence thro' the glass as it did

in the other case thro the air, and the conductor on the other side will be found in the Aphronte state. In these circumstances there is an eager attraction between the two conductors, and when a communication is formed between them, the equilibrium is restored by a bright sparke and a loud snap, and if the hand of an animal form part of this communication, the electric fluid passing thro it will convulse it, and produce a painful sensation called the electric shocke.

For the convenience of electric experiments, the glass electric used for these purposes, is put into the form of a Jar, and a coating of tinfoil fastened with Gumm covers the inside and the outside surface, excepting an inch

or two at the top which is left uncoat-
-ed to prevent the fluid flowing of its
own accord, and readily from the posi-
-tive side to the negative. A wire or chain
is then made to touch the inside, the
top of which is connected with the
prime conductor whenever the jar is to
be charged. When the inside coating,
by touching the prime conductor be-
-comes positively electrified, its atmos-
-sphere extending its influence thro' the
glass makes the outside coating nega-
-tive. But in order that it may do
this effectually, it is necessary that
the outside coating be connected with
the ground, that its natural share
of electricity may be driven away.
It is also necessary to the success of
the experiment that the glass be dry,

otherwise the influence of the positive atmosphere will not reach thro' it.

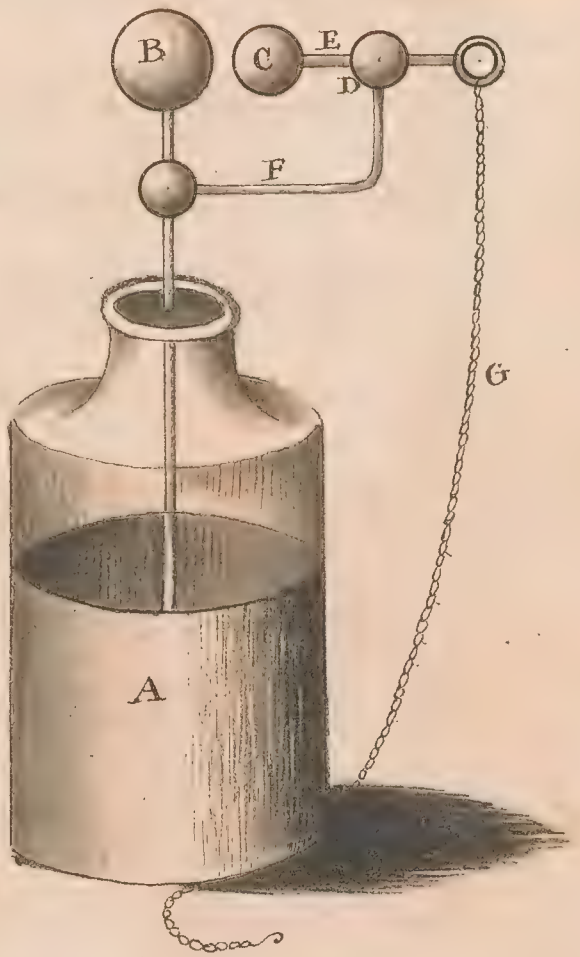
This apparatus is generally called the Leyden Phial from the circumstances of the accidental discovery of its effects. One of the Professors at Leyden having put a wire into some water in a common phial, and holding it with one hand, when the wire had received electricity from the proper conductor, he happened to touch the wire with the other, when he received a violent shock thro' his arms and breast. This was in the year 1745. The charge in a Leyden Phial resides on the surfaces of the glass. This is manifest from the following experiment. Place a plate of glass or piece of tinfoil con-

-nnected with the ground, and fast a piece of tinfoil upon it, connect this with the prime conductor, and when the apparatus is charged, remove the upper tinfoil with a thread of silk, and then take up the glass carefully, its upper side will be found positive, and the under side negative, but no signs of electricity will be found in the tinfoil, this removed in an insulated state. Put the apparatus together again as at first, and they will be found still charged. The charge then resides in the surfaces of the glass, and the tinfoil only serves the purpose of diffusing the fluid over the surfaces at the time of charging and conducting all away at the same time when the apparatus is discharged.

A Leyden Phial may be charged on the outside by taking hold of the wire and applying the outside coating to the positive conductor. In this case the jar must be set down on some electric or the charge will instantly disappear.

Tho' in general great care must be taken to keep electrical apparatus free from damp as well as dust, yet it has lately been found that a Leyden Phial will bear a greater charge when it is used without warming it first. The reason probably is, that the slight degree of moisture on the glass, giving the fluid a greater freedom to expand itself, the electricity on the coated parts is less intense, and thus a greater quantity may be

accumulated. As it is a matter of considerable importance to know the strength of a charge, various Electrometers have been invented. Of these, Jones & Henley's are the best. The first of these is used when it is intended to give a number of strokes in succession of the same strength. Its construction may be understood by the following figure.



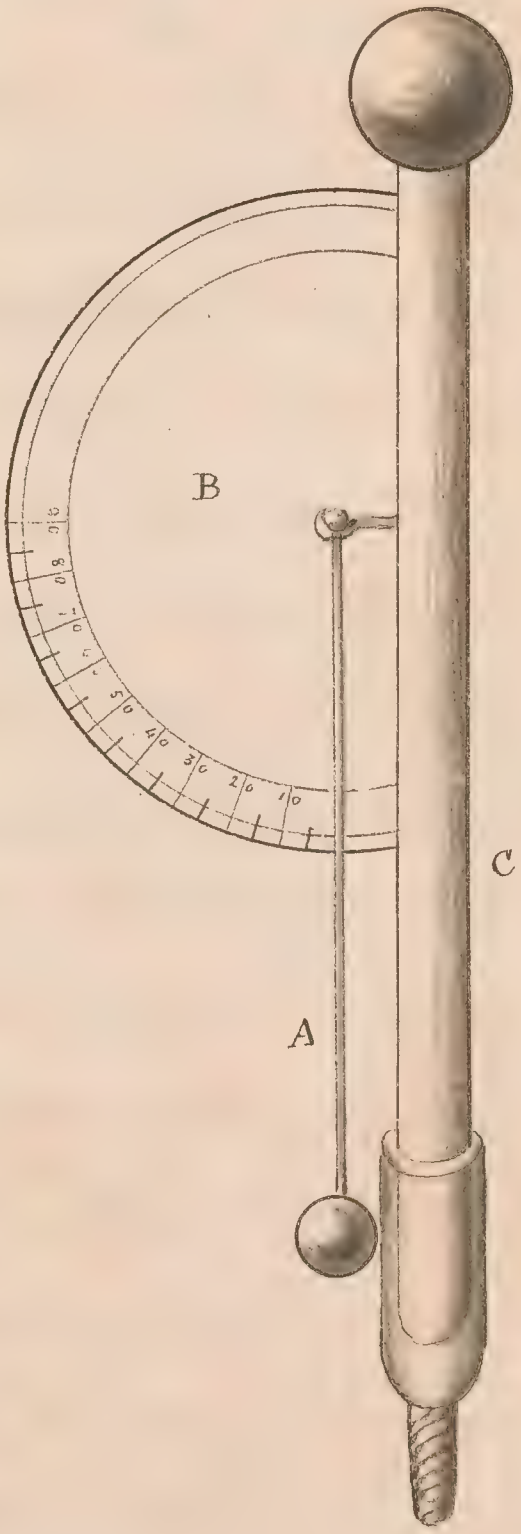
A is a Leyden Phial, B the knob connected with the inside coating C is another knob, fastened to the rod E which slides thro the brass piece D, and is kept tight

by a spring in it, F is a bent tube, or stick of glass designed to insulate the ball and rod CD; G is a chain making a communication between the ball C and the outside coating of the jar. The ball C may be set at any distance from B. Let the object or person to receive the stroke be put in the circuit between the chain G and the outside coating, and connect B with the positive conductor. If C be set near to B, a spark from B to C will soon discharge the jar, and give a moderate stroke, and any number of strokes may be given by continuing the application in the same position. If the strokes be required to be less, bring the balls nearer, if greater, set them farther asunder. The following is Hen-

-ley's electrometer.

A is a very light rod with a cork ball, made to turn on the semicircle B in such manner that the graduations on the edge may shew the diver-gency of A from the stem C. This stem may be plac-ed either on the prime conduc-tor or the Jar, and the diverg-ency of A will shew the strength of the charge.

It is obvious, this electrometer can only ascertain



the degree of the charge in the coated Jar, and our instrument is still wanting that would shew the absolute strength of charge in all Jars.

13. The strength of the charge will be in some measure in proportion to the extent of coated surface, and may be raised very high by connecting a number of coated Jars together, inside and out. A number of Jars thus connected is called a Battery. The strength of the charge however will not in the coated Battery be in proportion to the extent of coated surface, for where the surface is large it takes a considerable time to charge it, and all this time the fluid or it is collected, is exposed, thro' all the surface to the air, the moisture of which carries it off.

If the battery indeed be charged by a powerful machine the charge will rise nearer to the proportion of the extent of the surface as the time taken up will be small.

Where the battery is large, care must be taken that the circuit of conductors which is to form the communication between the outside and the inside be of some extent, otherwise the discharge may break some of the Glasses, and where the charge is high, precautions are necessary to avoid receiving the discharge accidentally. Dr. Franklin and others have been struck down senseless by such accidents, tho' there is no instance of any lasting injury having been received by them. After a Jar has been discharged it is always found

that a residuum is left; this residuum is probably a small quantity of the fluid which had been forced by the inverted surface, and which now returns gradually to the coated part. In a large battery this residuum is considerable, and the operator must take care to discharge it, if he would avoid the unpleasant sensation of a strong shock.

The force of Electricity accumulated in batteries is astonishing. Small animals forming part of the circuit are killed by the shock. Small wire is often melted in conducting the charge, and when very small it is exploded. Gold leaf between two pieces of glass, when made part of the circuit is often melted and struck

into the pores of the glass. The shock of a battery will also make a hole thro' a quire of paper which interrupts the circuit leaving a burr on each side, and if the brain conducting a strong charge be laid on paper it will strongly smoke it, and it will drive away light substances placed near it with great violence. This is called the Lateral Explosion. The strength of this may be shewn more remarkably, in the following experiment.

Take a short glass tube ½ Inch in diameter, fill it with water and stop the ends with pasteboard, then pass a wire thro' the pasteboard at each end, making the two ends within about touch, put this apparatus in the circuit of a battery, the tube will be blown

to pieces, and the water dispersed by the stroke.

14. With regard to the circuit, the fluid takes in passing from one side of the charged glass to the other, this is always the shortest it can find thro good conductors, yet notwithstanding, where there are several circuits of equally good conductors, tho' most of the fluid will pass thro the nearest, some will be conveyed along the more remote. Where a shock has been sent thro' the largest circuit it has not been found that it took up the smallest portion of time in performing the passage. 180 Soldiers joining hands once formed part of a circuit and seemed all to be convulsed at the same time. In an

= other experiment the shock seemed in =
= staintaneous thro' 11,276 feet of wire.
The river Thames at Westminster bridge
was once made part of a circuit. A
charged Jar stood on one side, and a wire
from the coating outside passed over
the bridge. A person at the other side
held the end of this in one hand and
touched the river with an iron rod in
the other. Another person then on the
side where the Jar was, touching the
river with an iron rod in one hand dis-
charged the Jar with the other. Both
the persons received the shock, but the
person nearest the Jar had it more
strongly; some of the fluid probably
passing thro the persons feet into
the ground, where; thro' the moisture,

it found a nearer passage.

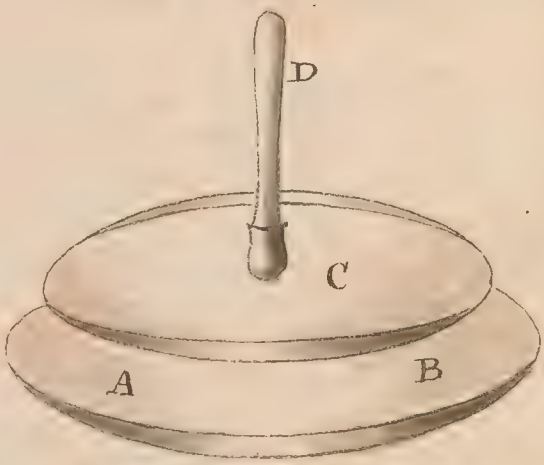
A number of beautiful experiments are made in the dark in which the shock is sent thro' circuits which are differently interrupted, a flash of light appearing at every interruption. The gilding on a picture or the back of a book made part of the circuit appears very luminous. If the circuit be interrupted in Inch and a decanter of water stand on this interruption, when the discharge is made, the spark at the interruption will illuminate the water and the whole room. The fluid passing thro the Boyleans lamman will also appear very beautiful in the dark. It cannot pass thro' a perfect void, but in an imperfect vacuum where most of the air, which is our electric, is removed, the

few remaining particles thro' at a great distance from each other, easily conduct it. The purple appearance of the light here and the manner in which the fluid seems to pass, shew that the Aurora Borealis is electricity.

Where a more copious stream of electricity is sent thro' the vacuum, the light is more white, and if a strong charge be passed thro' a long exhausted Jar, its colour is very white and vivid, and it passes in a dense looked part like lightning. These circumstances shew that the whitest sparks of Electricity are the strongest, and that in proportion as they approach to a purple they are weaker.

115. Some years ago Sig. Volta invented an instrument called the

Electrophorus which with a very slight excitation at first will continue for a very long time to communicate electricity. The annexed figure will shew the parts and the uses of this instrument.



AB is a circular plate of glass with its upper surface covered with a coating of sul-phur or wax, or resin and made smooth. C is a plate of metal now placed on the other plate, and D a glass handle fixed in it. If the surface of the plate AB be rubbed with flannel and slight-ly excited, it will then be in the nega-tive, the surface being of the resinous

class. In these circumstances apply the metal plate C to it. This plate will not receive a spark from the electric, the excitation being too weak for that, but its lower surface coming into the atmosphere of the electric will acquire the opposite state and become positive and consequently its upper surface will be negative. In this situation touch the upper surface with your finger, and it will receive a small spark from you, and now the plate will contain more than its natural share, and upon being removed by the insulating handle, the electri-city it contains will be equally dif-fused thro' the whole, and the plate will be positive and give a spark to

your knuckles or any other conductor that may approach it. If now the metal be again applied to the electrix, its upper surface will again become negative, and will receive a spark, and the whole plate, when removed, will be positive as before, and communicate electricity. This process may be continued for a very long time, for the electric spark will take no electricity by the operation, and in so doing create a state of electricity the dampness of the air does not soon restore the equilibrium, there being no eager attractions, and the resinous surface is not so soon covered with damp as a piece of glass.

The whole apparatus may be packed in a small tin box (as the handle screws into C) and carried in

the pocket, and as it will in a little time charge a small pitial, it may be convenient when going to places where no machine can be procur-
-ed.

16. Some years after the invention of the Electrophorus the same Professor Volta invented another instrument acting upon the same principle but of more useful application. This was the Condenser of Electricity, its object is to ascertain the existence and quantity of electricity in bodies of large surface where the electrification is so very weak as not to be discoverable by any other means. The apparatus is some-
-thing similar to the Electrophorus, only in the room of the plate AB a piece of dry marble is used with its

surface covered with copal varnish.
When the instrument is used this
varnish is not to be excited, but it is
necessary to the experiment that it be
perfectly neutral. The metalic plate
is then put upon it (the marble be-
-ing circumstated). The body then to
be examined must be connected with
the metal plate, and if it contains
any electricity at all, it will begin
to impart some of it to the metal.
The metal being thus slightly elec-
-trified will put the surface of the
marble into the opposite state, the
thin varnish serving as an electric
to prevent communication by sparks.
The marble surface now electrified,
re-acts upon the surface of the metal
contiguous to it, and makes it more

strongly electrical so that its opposite surface will take the electricity thereon freely from the body to be examined. The connection between this body and the metal plate should continue 8 or 10 minutes to give the weak electricity of the body time to expand itself into the metal. This body is then removed, and the metal plate taken up insulated by the handle when it will shew the electricity of the body in a condensed and very sensible state. Very wood, without varnish, may be substituted for the varnished marble, and then the very thin plate of air between it and the metal will serve for the electric. Or the apparatus of the Electrophorus may be used,

only covering the lower surface of the metal plate with very thin silk. It is found however that dry marble, wood &c. which semi-insulate the metal plate do best for the plate AB, the metal plate is more strongly influenced, and therefore receives the electricity more freely from the body to be examined.

The condenser is chiefly used to examine the electrical of the Atmosphere. An insulated rod of metal rising prominent above the building and which may be supposed to receive the electrical state of the surrounding air, is connected by a wire with the metal plate of the condenser and thus its state is ascertained.

But it is also used to ascertain low degrees of artificial electricity. Mr Cavallo has carried the purposes of this instrument still further. When the electricity even of the condenser itself, is so small as not to affect the most delicate electrometer, he produces a sensible degree of electricity by applying it to the metal plate of another and smaller condenser, the size of which does not exceed a shilling. It is certainly of great consequence to be able thus to examine the low degrees of electricity in bodies and particularly of the atmosphere, for a knowledge of the very commencement of electrification may be expected to throw considerable light on the

nature of the electric fluid, and on the dangers which it produces in bodies.

17. To promote this desirable end, another instrument has been invented by Mr. Bennett, to detect very small degrees of electricity in bodies. This is the Doubler of Electricity. The principle of it is this. By the semi-insulated plates of M. Voltas condenser, diffused electricity is attracted and condensed into a small compass. When one plate has received electricity, positive for instance, another is laid upon it, and the atmosphere of the first, repelling the electric fluid from the second (which is touched with a conducting substance, to carry off the fluid) produces in

this second an equal negative electrici-
-ty, without losing any of its own:
the second is, in like manner, made
to produce an equal positive electrici-
-ty in a third: the first and third,
now both positive, being put toge-
-ther, act with double force, and the
second, laid upon them, acquires an
electricity, nearly double to the first,
and by repeating the process, the
smallest degrees of electricity, continu-
-ally doubled, soon become sensible.
This instrument has been found
of great service. Mr Cavallo how-
-ever has pointed out one error to
which its results will be liable, if
great care be not taken. He says,
that if the plates employed contain

any electricity, this will in the pro-
cess be doubled as well as that of the
body to be examined, and falsify
the result. And these plates, threads,
and almost all bodies, do in fact,
possess at almost all times some de-
gree of electrification. He considers
the excitation by rubbing as be-
ing only a rapid doubling of some
small quantities electricity that hap-
pens to be on the glass or rubber.

13. At any early period in the progress
of electrical discoveries, it was strongly
conjectured that lightning was elec-
tricity, and Dr Franklin proposed
as a method of determining
the point, that an insulated
rod should be raised to a great

height by being attached to a very high building, & that it should stand pro-minent above it, and end in a point. He imagined, that if lightning and Electricity were really the same thing, the insulated rod would be electrified by the lightning, that might be oc-casionally diffused thro' the air. While he was waiting, however, for the finishing a high steeple in Philadelphia that would be proper for this purpose, another method occurred to him. He thought that a kite raised high in the air would probably be electrified. This experi-ment he immediately tried, tying a key to the end of a string, and insulating the whole by a silk

board here brief. He is experiment com-
pletely succeeded. The key attracted
and repelled light bodies, gave sparks,
and in all respects exhibited the same
phenomena as an insulated conductor
electrified by a machine. He is first has
found had, however, been tried in
France in the mean time, and found
to succeed. In the experiment with
the kite, some wire connected with the string
should stand above it, and the string
should be made a conductor by a small
wire twisted with it, or by being well
soaked in brine. The kite has been
much employed in examining the elec-
trical state of the atmosphere. But
as it is inconvenient to conduct experi-
ments in a field, insulated rods,
such as Dr. Franklin first recommended

have been preferred. The lower end can be brought into a room where convenient apparatus can be had. Precautions in the use of such rods are very necessary. Professor Richman of Petersburg was killed by a spark from one by bringing his head too near it in order to examine its state during a thunder storm.

The experiments made with lightning thus procured, have proved beyond a doubt that it is electricity. Indeed almost every appearance of the one may be paralleled by experiments with the other. Dr. Priestly, in his experiments in Natural Philosophy Vol. 4, pp. 379, mentions an experiment made by Mr. Arden in which the fluid was so highly accumulated that it even assumed the appearance of a fiery ball; similar

to those sometimes seen during a thunder storm. He charged a Jar of 3 or 4 Gallons, and to prevent a spontaneous discharge, he fixed a wire communicating with the inside thro' a glass tube. When the jar became very highly charged, a ball of fire appeared in the jar about ½ Inch diameter, it ascended up the tube turning on its axis, when it came to the Conductor, it stopped a little, and then descended, and when it got within the Jar, the jar broke, there was a great flash, and the ball disappeared. This experiment has been often repeated, but without success.

The discovering that lightning is electricity has led to the invention of securing our persons and dwellings during the dangers of a thunder storm.

A building is secured by a metal rod, well connected with the ground, fastened to the walls and reaching above the highest part of the house, where it terminates in a point. Care must be taken that the rod be effectually connected with the ground and the point free from rust. Where conducting rods have failed to answer the intention, there can be no doubt it has been owing to their being faulty in one or both these respects. To prevent the fusion or calcination of the top, the best method seems to be to make it terminate in a narrow piece of black lead finely pointed, and to secure a good communication with the ground, the bottom of the rod should be of tin or copper, not so liable as iron to corrosion, or if iron, it should be coated

with a compound of black Lead & Sulphur, and there this extremity should be surrounded to a consider-
-able depth with charcoal. If the building be extensive there should be several conductors all connected by rods on the roof. There are some facts which prove that one in such cases is insufficient.

The property of these conducting rods being pointed has been strongly questioned by Mr. Wilson, who advanced some arguments to prove that blunted ones would be preferable. He contended that points solicit the lightning, and so bring on a stroke. But to this it was replied by Dr. Franklin and others, that the contrary is the fact, and that

they often prevent a stroke. When a charged cloud comes near the top of a building, the building attracts the fluid in it and collects it from the remote, and if it come within striking distance, it discharges its contents upon it. But a pointed conductor upon the house would immediately act upon the cloud, and at a considerable distance and discharge its electricity silently and gradually, and this it will do without attracting the cloud at all. Nay, there points evidently repel those clouds which are light, and fly low, and are in danger of being attracted by the building. All this may be substantiated by the following experiment.

Hang a loose lock of Cotton from the

charged conductor by a linen thread, the loose pieces stretch towards the Table and every object near them, and a blunt conductor brought under them only attracts them, but a point soon discharges their electricity, and they rise up from it, being now attracted by the brighter points, and these are afterwards discharged, and approach the conductor. It is certain that these pointed rods do often discharge electricity. Dr. Franklin had one which came down by the wall on his stair case. In a convenient situation he made an interruption in it, setting the two ends two or three inches asunder in an horizontal direction and fastening a bell

to each end. Between these bells be hung a ball on silk. Whenever a thunder cloud passed over his house the bells would ring: the ball on the extremity of the upper wire, charged with the fluid, attracted the ball, and when the ball was charged by it, it was attracted to the other bell, to which it imparted its electricity, and was there attracted by the first bell. On one occasion the quantity of electricity was so great, that the ball was thrown out of the course, and a dense stream of the fluid passed from one bell to the other.

In houses where there is no conductor, the place of personal safety is in a cellar, and if there be none sufficiently

under ground, there in the middle of a large room, and as much insulated as possible.

Besides the danger to be apprehended from the direct discharge of electricity mischief may be occasioned (tho' perhaps not often) from the returning stroke, the nature of which was explained in §9. Lord Stanhopes idea respecting this danger will be more easily understood the following sketch. Let A, B, C, represent a thunder cloud and F D E, several places on the ground beneath it. If a person stood at E the positive atmosphere of the cloud will make him strongly negative. Now in these circumstances, let the other end of the cloud C come so near the house at E as to strike it, the cloud

now discharged instantly, the natural electricity will suddenly return into the man at F, and produce violent and perhaps fatal effects. A thunder cloud may be so extensive, that F may be distant from E a mile or two, and while there is danger at F and E, a person at D may be safe, the cloud above him at B being too high to endanger him either

by a discharge or the returning stroke.
These circumstances however, cannot be supposed frequently to appear.

19. As to the means by which the air becomes electrical, and by which Thunder Storms are produced, various conjectures have been formed. Some have thought it is by heat alone, and they have thought this conjecture confirmed by several facts in which the electric state is given to bodies by heat merely.
A gem called the Tourmalin brought from the Island of Ceylon becomes electric by heat, one side positive, and the other negative, and if this electric state be taken off it acquires it again by cooling, only the side which before was positive is now negative.
The Brazil topaz and some other

gems have likewise in some degree the same property. Sulphur also in melting, and then by becoming solid again, in certain circumstances, acquires the electric state. It has not indeed been discovered that air has this property. Considerable light has however been lately thrown on this interesting subject by some experiments made by Sig Volta with his condenser. In these experiments it was found that when water was evaporated from insulated hot coals, the coals and vessel containing them were left in the negative state, and subsequent experiments with the Doubler have proved that the electric state is produced whenever a solution or precipitation takes place between two bodies, and

more especially when air absorbs, or depo-
-sits, moisture. These facts seem to furnish
the clearest evidence, that the immense
processes of evaporation and precipita
-tion of water constantly carried on by
nature, are the means of electrifying
the atmosphere, and there are many ex-
periments which prove that whenever
any portion of the atmosphere is in a
state to take up an additional quanti-
-ty of moisture, it is in a state at the
same time to take up more electric fluid.
and on the other hand, when it is part
-ing water it is parting with electricity.
This opinion respecting the means by which
the atmosphere acquires its electric state,
we shall find to be very strongly confirm-
-ed, if we consider the frequency and
violence of thunder storms in those sea-

-sions and countries in which evaporation
is the most copious. In the tropical regions,
where the intense heat of the sun causes
the greatest absorption of water by the at-
-mosphere, electrical phenomena are the
most tremendous; and in our climate,
thunder storms are the greatest and
most frequent, during the summer
months when evaporation is the most
rapid and abundant. In the neigh-
-bourhood also of volcanos, when the
air is heated to a vast extent by seve-
-ral square leagues of red hot lava,
and swallows up an immense quan-
-tity of aqueous vapour, the thunder is
frequent and tremendous. In like
manner, a dry wind passing over a
moist soil produces a very rapid eva-
-poration, which is generally attended

by violent Thunder. This is in many instances the case in Africa, where a current of air roasted in its passage over a great extent of burning sands blows upon a marshy district.

On the coast of Guinea, the wind called the Harmattan which is so hot and dry as to wither and pulverize every thing it meets, no sooner mixes with the cold air from the ocean, than it produces the most dreadful hurricanes of wind & lightning.

In tropical countries evaporation is carried on to a prodigious extent. The air becomes more and more loaded every day for months together, till at length the atmosphere is the reservoir of vast rivers. The sun now passes the line, and the wind

changes and mixes colder air with that which is then heated and loaded with vapours. This produces the most copious condensation, and the rain is so excessive as to inundate whole countries, and these condensations are attended with storms of thunder far exceeding any thing we in this climate ever conceive of.

These facts, and many others of a similar nature, that might be mentioned, seem to furnish undeniable evidence that the cause which has been assigned, is the cause which really produces the electrical state of the atmosphere; and this cause, if it be properly considered will also account for what has generally been considered as very difficult to explain, that is

the continued discharges from the same cloud during a thunder storm. It might be imagined, upon the known principles of electricity, that when an explosion once takes place from a cloud, all its electricity would be discharged, and that the stroke could not be repeated, but we find not only a repetition, but in many cases, a rapid succession of discharges for a considerable period. In tropical climates this succession often keeps the sky in one continued blaze of lightning for hours together. This phenomenon, we shall soon find will be fully explained by the cause which has been mentioned. On the commencement of such a thunder storm as we are supposing, the air is to be

considered as loaded with vapours to a considerable extent; when therefore, in any part of this portion of air, a discharge happens, a condensation of the vapour at the place must follow, this produces a partial vacuum; to fill up this, the air on all sides unites in and more especially from the denser and colder parts above; this instantly produces a further condensation, and furnishes a fresh portion and charge of electricity, another explosion therefore takes place, this is followed by a fresh condensation, and another partial vacuum, this instantly occasions a new condensing mixture of cool air with warm, and another discharge follows, and thus a repetition of strokes is continued,

till the air which rushes in to supply these vacuums becomes of such a temperature that its mixture with colder air will no longer produce such condensations as will furnish sufficient electricity to make a discharge.

With regard to the direction of these discharges, they are no doubt, often made from a positive cloud to some negative part in the ground, and vice versa, but much more frequently from cloud to cloud. When vapour ascends taking with it positive electricity (as it has been shewn that it does) a cloud may be supposed to be formed in this distrikt electrified below, the atmosphere of this would influence a neighbouring cloud and make it minus. This frequently happens, and when the opposite

states are carried to a considerable degree, discharges from one to the other must ensue.

20. The appearance of the electric fluid while passing thro' a vacuum as noticed § 14. bears so strong a resemblance to the Aurora Borealis that we are naturally led to consider this phenomenon as electrical, and in this conclusion we are confirmed by several other circumstances. There are however particulars attending this appearance which philosophers have found it difficult to explain. It always appears to us in the North, and darts its coruscations Southwards, and to persons who live in Southerner latitudes, it is seen rising from the North towards the South pole, and streaming north.

Captain Cook tells us that in high
Southern latitudes the aurora aus-
tralis appeared peculiarly vivid.
In high northern latitudes likewise
this phenomenon is far more consi-
derable than here. It gives consider-
able light in Lapland, and Professor
Gmelin speaks of it as being attended
with a loud hissing noise in the
South East parts of Siberia. "Whoever
" says the Professor) should see such
a northern light for the first time
could not behold it without terror,
for it is attended with such a hiss-
ing, crackling, and rushing noise
thro' the air, as if the largest fire-
works were playing off" and the
expression by which the country
people describe it is, "The raging

host is passing". The hunters on the confines of the icy sea, when overtaken by these northern lights find their dogs so much affrighted that they lie obstinately on the ground till the noise has passed." To account for these circumstances, and particularly for the streaming of these lights from the two poles. Dr. Franklin has suggested a most ingenious and satisfactory theory, which was published in his miscellaneous Tracts under the modest title of "Suppositions & conjectures toward forming an hypothesis for the Explanation of the aurora Borealis."

"The air heated between the Tropics (says the Dr) and containing a great quantity of vapour, replete with

electric matter is rendered light, and accordingly rises into the upper parts of the atmosphere, and after spreading northward and southward on the different sides of the equator, it finally descends near the two poles, from whence an opposite current of cool and dense air is, at the same time, put in motion towards the equator, to supply its place. In the passage of the electrified vapours to the northward (for instance) in the form of clouds, great part of it is precipitated before it arrives at the polar regions, in rain, snow, or hail. In the temperate regions this electricity is readily received and imbibed by the earth, which in those climates is a good conductor, and which will receive it, either silently conveyed to

it by the rain &c, or suddenly in the explosions attending thunder storms. In the cold polar regions however the case will be different. That part of the electrified vapour which reaches there, and descends with the snow, does not fall on conducting earth, but on a uniform cake of ice with which the earth is eternally covered, and which (particularly when the cold is extreme) will not conduct electricity. The electric matter therefore, not being able to penetrate thro' this non-conducting stratum, will be accumulated on the surface of it as on a plate of glass. This plate of ice thus becoming overcharged, the electric matter will, at different times, burst from it, as happens when a pistol has been

overcharged, and will break thro' the su-
-perincumbent atmosphere (lower here
than at the equator) till it arrive at the
vacuum, or highly rarified air above,
which is a good conductor, where it will
run along towards the equator, diverg-
-ing as the degrees in longitude enlarge,
and exhibit appearances resembling
those which the electric matter is known
to present in our experiments made on
a vacuum."

While we are admiring the satisfactory
manner in which this hypothesis ex-
-plains the phaenomena of the auro-
-ra Borealis, it is impossible not to
notice the accurate conjectures this
great philosopher had made re-
-specting the electrification of the
atmosphere by the formation and

ascent of vapour. Had he been acquainted with such means as the Condenser and Doubler of ascertaining the presence of very small degrees of electricity, there can be no doubt that the true cause of the electric state of the air and of thunder storms would, in his days, have been explained and understood.

21. Those large fiery meteors or fire balls, which sometimes appear in motion in the higher parts of the atmosphere, are now generally understood to be electrical. A very extraordinary ball of this kind made its appearance in this country Aug. 18, 1783. It was seen from so many places, and so many observations were made on its size and motion that many interest-

-ing particulars were ascertained respect-
-ing it. Dr. P. Bagden has published
these in a very curious paper in the
Phil. Trans. Vol. 74. It is calcula-
ted to have been about 57 miles high,
and half a mile in Diameter, to
have described a course of about 1000
miles from north to south nearly in
the direction of the magnetic meri-
dian, and with the amazing velo-
city of at least 20 miles in a second.
Another fireball similar but smaller,
appeared the 4th of October following.
Dr. P. Bagden in this paper assigns
very strong reasons for considering
these balls as masses of the electric
fluid; either repelled, or bursting
from the great collected body of it
in the north, or attracted towards

that accumulation. An appearance similar to those, in one instance, produced by artificial electricity is mentioned. S^e 17. page 48. 22. Shooting or falling stars, are generally now considered as electrical appearances.

Ignes fatui, are thought to be hydrogen fired by Electricity. Some indeed consider them as Photistical appearances.

Water spouts likewise are imagined to be produced in part by Electricity: the water is thought to be raised in the vacuum made by a whirlwind, by the pressure of the atmosphere, on the surface of the sea, and then a cloud highly electrified over it is bent down towards it by electric attraction, and bent down till they join

A drop of water suspended from the charged prime conductor will be found to be thrown so completely into a conical form, stretching its vertex downward, as strongly to favour this hypothesis.

23. The electrical phænomena which have hitherto been noticed, admit of an easy and satisfactory explanation upon the principles of the Franklinean theory. There are however, facts which may seem more difficult to be accounted for upon these principles.

There is a fish, common in the Mediterranean, which, in all ages, has been famous for benumbing the hand of the person that touches it, and has on that account been called

the Torpedo. Now this benumbing effect has been proved to be electrical. Mostly takes place when the fish is touched with conducting substances, and like the common electric shock, it has been communicated to several persons, at the same time insulated and connected by conductors.

Some years ago a species of Eel was found in the river Surinam in South America, which possesses the same property, and in a still higher degree. It has given very strong shocks to persons angling in the river, and several instances are mentioned in which this animal has given smart strokes to persons who have had their hands or feet in the water where it has been fishing. Upon the first discovery of

these Eels, the Royal Society in London had several brought over for their inspection, after which they were exhibited in various parts of the country, and great numbers received the shocks from them. They lived chiefly upon small fishes which they seized to stun with the shock before they devoured them. Upon what principles the fluid could be accumulated and impelled in these animals, so as to produce these effects at the will of the creature, has always been a question very difficult to be solved upon the known principles of Electricity, and yet it is certain that the shocks these fishes give is electric, for besides the circumstances above mentioned, the sparks of explosion in a stroke from these Eels has actually been exhibited. A slip of

tinfoil, making part of the circuit was pasted upon glass and divided by one stroke of a sharp knife. At this break the spark was seen very luminous and bright.

14. Electrical phænomena, however, still more extraordinary have lately been noticed, and the very great attention which these have excited, has been the means of throwing some light, not only upon these facts themselves, but upon the electric effects produced by the Torpedo, and the Eel of Surinam.

About the year 1790, Galvani, professor of anatomy at Bologna discovered that in the limb of a frog, or other small animal recently killed strong contractions were produced by touching it with two metals of different kinds which at the same time touched one another either

immediately, or by the intervention of some other substances capable of conducting electricity. The experiment is made thus. About an inch of a great nerve, leading to any limb or muscle, is laid bare. A piece of zinc is then brought into close contact with the remote end of this bared part, and a silver wire or probe is made to touch this zinc with one end, while its other end touches either the naked nerve, or the muscle or limb to which it leads. Violent contractions are instantly produced in the limb or muscle. It is essential to the experiment that the two metals employed be of different sorts. Zinc is found to answer best for one of the metals, and for the other Gold is best, after that Silver, then Molybdena,

steel & copper. But besides these contractions, the Galvanic influence (as it has been called) affects the organs of sense. If a thin plate of Zinc be placed upon the tongue and an half crown piece be put to its under side and then the edges of the metals projecting before the tongue be made to meet, a peculiar sensation of taste is produced on the tongue the instant they come into contact. If one metal be applied as high as possible between the upper lip and the gums, and the other in a similar situation to the lower lip, a very vivid sensation, like a flash of light, is perceived the moment the metals are brought into contact, and another at the instant of separation. The taste above mentioned may be communicated to water.

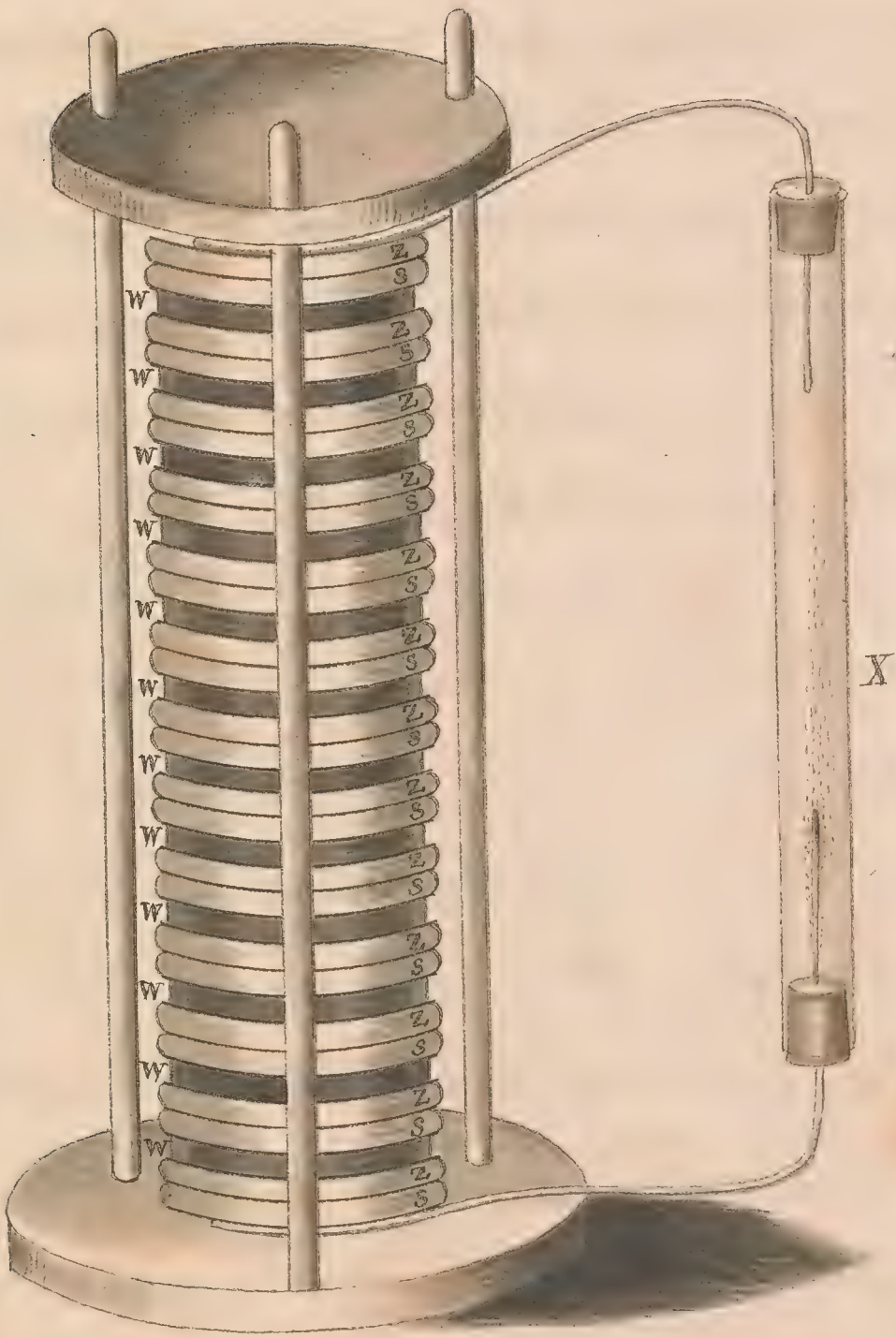
If a cup of Zinc or even of tin, be filled with water, and placed on a silver stand, and the tip of the tongue be dipped in the water, it will be found insipid, but the moment the silver is touched with the hand well moistened, a strong acid taste is distinctly perceived. Porter is generally said to taste better from a Pewter vessel than from one of Glass or Silver, and it probably does, as Pewter is a mixture of metals.

25. While Philosophers in various parts were pursuing these experiments, Sig. Volta discovered the means of producing a vast accumulation of this power. This important discovery, communicated to Sir Joseph Banks, March 1800 has excited

wonderful attention to the subject of Galvanism. Volta's apparatus is a pile of half crowns, plates of Zinc of the same size, and pieces of moistened card or cloth. A piece of Silver is put at the bottom, then upon it a piece of Zinc, and then upon that a piece of card, then another piece of Silver, a piece of Zinc, and a piece of wet card, and so on in the same order till the pile be completed. The pile is preserved in a perpendicular posture by three rods of Glass stuck in a piece of wood at the bottom, and passing thro' another piece laying on the pile, at the top. The whole apparatus is represented in the annexed drawing. The pieces of card should be well moistened, and then gently squeezed before

they are applied, that no wet may run down the pile, or get between the pieces of metal. This apparatus, yields a constant current of the electric fluid, or Galvanic influence, thro' any conductor communicating between the highest and lowest plate, and any person, forming the communication with his hands, will feel a shock as often as the contact is renewed. This shock gives a sensation rather different from the common electric shock, it is not so instantaneous, and is attended with a jarring kind of feel, like the shock of the torpedo, or eel of Surinam.

Its strength depends on the height of the pile. When this is low it is often found necessary to wet the hands before



they touch the wires which communicate with the top & bottom of the tube, for it is found the Galvanic influence does

not readily pass thro' the Cuticle. A pile of 20 pieces each gives a shock very sensible, on the arms, and when 100 pieces each are used, a very severe shock is felt, even in the shoulders. In a darkened room a small but vivid spark is often seen when the contact is made with good conductors, the pile should be large for this purpose, and it answers best when the contact is made by two me- -tal knobs. Even the snap has been heard when these have been used.

In a day or two the pile will lose its power, and in order to renew it, the pieces of zinc which are found corroded must be cleaned either by a file, or sand paper, or, which is best, by putting them into diluted muriatic acid.

It seems certain the effect of the pile

is electrical, for besides the other evidences, it has been proved to be so by the Condenser, and a jar has been charged by it, and with respect to the peculiar feel of the shock, and the smallness of the spark, these are similar to what are witnessed when a very low charge of a large battery is received. A small jar, highly charged, gives a quick shock, with a loud snap, and bright spark, but the same quantity of the fluid in a battery gives a duller stroke, tho' of the same strength, and the spark is very small and flies scarcely any distance in comparison with the distance in the other Case.

As to the cause by which the electricity is produced in this apparatus, it seems to be done by the action of the water in

the cards, upon the zinc plates, these are not corroded if the water used be distilled and pure, and then no Galvanic effect is produced. It was long ago observed by Volta, that the electric state is produced wherever one body acts upon another, this is noticed in SS . With regard to the experiments, before the fate of Volta was known, it is probable the two metals, used in them, have some chemical effect on each other, upon contact. The whole subject, however still remains in much obscurity.

The action of the torpedo and electrical eel, is considered by some as produced by an apparatus in some respects similar to the pile of Volta.

Anatomists have found their electric organs to consist of numerous mem-

- brazen columns filled with a great number of plates seperated by very small intervals, filled with a fluid. When the animal gives a shock, it is probable it contracts the columns and brings these plates into contact.

26. If the circuit of Volta's pile be taken thro' a column of water, the water will be decompounded by it. This is one of the most curious and important effects this pile produces, but as this part of the subject belongs to Chemistry, I shall not enlarge upon it here, but give merely a brief statement of the facts.

The glass tube X in the last drawing is six inches long, and half an inch in diameter, it is filled with distilled water, and corked at both ends. Two

copper or iron wires communicating the one with the top, and the other with the bottom of the pile are then passed thro' the Corks, so as that their ends may be 2 or 3 inches from each other in the water, as in the figure.

When this circuit is completed, the lower wire in the water coming from the silver at the bottom of the pile, will very soon be covered with small bubbles of air, and immediately these bubbles will increase into a fine stream of air, which of course rises to the top. At the same time, no air is seen about the other wire, but a cloudy film is formed round it, which continues to fall from it, so long as the process is continued.

Now water is a compound substance and its component parts are two airs,

the one called hydrogen, which is inflam-
-mable, and the other oxygen, this air
combines with metals, and forms them
into oxides, or oxids. In this process, the
fluid in its passage, decomposeds the
water, the oxygen of which unites instant-
-ly with the wire coming from the zinc
at the top of the pile, and forms the
cloudy oxid which is seen to fall, and the
other air, the hydrogen, rises from the
wire connected with the silver and remains
at the top uncombined. When this air
is examined it is found to be pure hydro-
-gen. When both the wires in the experiment
are gold, which cannot be acted on by
oxygen, air arises from each, the water
as before is diminished, and the air re-
-sulting from the experiment is found
to be a mixture of oxygen and hydrogen.

Where the tube is filled with a solution of Acelite of lead or distilled water, no air is seen to come thro' from the wire connected with the silver, but in a few minutes, beautiful metallic needles are formed on its extremity and soon increase and take the form of fern or other vegetable. The hydrogen metalizes the salt of lead. These experiments shew that the Galvanic influence is a very powerful chemical agent, much more so than electricity from a machine.

97. I shall now close this account of electricity with briefly mentioning, that the electric fluid has been found to promote vegetation. Dr Darwin thinks its influence in this is so considerable that in a late work he has proposed a scheme of conductors for gardens to attract the

fluid from the air.

Electricity has also been employed as a medical agent, and in some cases with success, particularly in rheumatic & paralytic cases, and agues.

It is probable, however, these applications would be more effectual could they be continued for a longer time. The pulse is quickened by it, and a stimulus given to nature.

The experiments in Galvanism, seem to give the hope that electric means may be discovered of easing or removing many bodily pains and disorders.

A powerful current may, by the pile of Volta, be sent thro' a diseased part for a long time, and the experiments in Galvanism shew us what a powerful agent it is on nerves and muscles, and

even in a dead animal.

Magnetism.

Magnetism is one of the most remarkable species of attraction in nature. Its effects are so common & striking, that they have engaged the attention of men in all ages. But tho' we have been able to turn our acquaintance with them to valuable uses, the cause of them still remains concealed.

What I propose in this account of the subject is, briefly to point out the several properties which have been discovered of the magnet to lay before

give the most plausible conjectures respecting the cause of them and to mention the uses to which we are able to apply our knowledge of these properties.

The first & most obvious property is that it attracts all bodies of steel, but the magnet attracts these bodies only. It has indeed been discovered lately, that in some slight degree it attracts Nickel & one or two other substances, but this perhaps may be owing to some small mixtures of ferrugenous matter with them.

The attraction of the magnet, for steel will exert itself thro' all other bodies that are not steel. A needle for instance placed on a plate of glass will be attracted by a magnet put under it. This property of the magnet has been used in a

variety of curious deceptions.

In every magnet there are two points which attract steel with greater force than the other parts, & these are generally at the extremities of the body. If one of these points be presented to another body that is magnetical, it will attract one end of that, but will repel the other. The other point of the first magnet will repel this but will attract the other. Where the attracting & repelling points of a magnet are at the extremities, the power diminishes as you proceed from these extremities to the centre of the magnet, this centre is neutral. A small needle suspended by thread over the centre will not be attracted by the magnet, but lie over it in a direction parallel to it.

Another remarkable property of the magnet is, that when it is suspended freely, it arranges itself so that the attracting extremities we have been speaking of, point towards the poles of the earth, & from this remarkable property these attracting extremities are called poles of the magnet, & because that which points to the north will always point to the north, it is called the north pole of the magnet, the other which points to the south is called the south pole for a similar reason. In any two magnets there is a strong mutual attraction, between the north pole of the one & the south pole of the other, but when poles of the same name are presented to each other a strong mutual repulsion is found

to obtain between them.

The dip of the needle is a third remarkable effect of magnetism. If you take a needle, which does not possess the virtue, & balance it nicely upon a point so that it may stand in any horizontal direction, & then make it magnetical, its balance will be destroyed, one end of it, what is now a north pole, dipping down in a considerable angle.

To these distinguishing properties of magnetism, may be added a fourth, which respects the manner in which the property is connected.

The natural magnet, or the substance found possessed of the property when first taken out of the earth, is a hard & heavy piece of iron ore, of a dirty black colour, & is called the

load-stone, in this magnet the poles are seldom well pointed, so that to concentrate the force of each, plates of steel are generally spread over the parts where the poles are found chief-ly to lie, which plates are called the armour of the load-stone.

But besides these natural magnets, it is found that a bar of iron acquires the property by standing a long time in a perpendicular posi-tion. Even the fine poker & tongs are found magnetical where they usually stand in an exact posture, but by a change of position the pro-perty soon leaves them. Notice also quenched with water in the position of the dipping needle be-comes magnetical.

Any of these substances possessing

the property will communicate it to iron or steel merely by rubbing them with it & the property communicated will be so much stronger that the artificial steel magnet possesses the property with as much permanency & with even more strength than the original magnet itself, & it is more convenient for use, on account of the shape you may give your steel, & on account of your being able to bring the poles of the steel magnet to points & placing them on the extremities. The artificial magnet will communicate the property to other iron or steel with greater convenience & strength, so that these are generally used for all magnetical purposes, & the loadstone is but little regard-

-ed except as a matter of curiosity.

The following is the manner of communicating the property.

If two equal, steel & uniform magnetical bars, with flat ends, be placed together endwise, the contrary poles touching each other, they will form one single magnet, & will communicate a strong degree of magnetism to another bar by the following process; Let the last mentioned bar be laid in the direction of the magnetical meridian, & let the others, each of which ought to be at least as long as the bar to be impregnated, be laid upon it in their conjoined state, so that the place of junction may be over the middle of its length, & their poles in the proper direction. Then separate

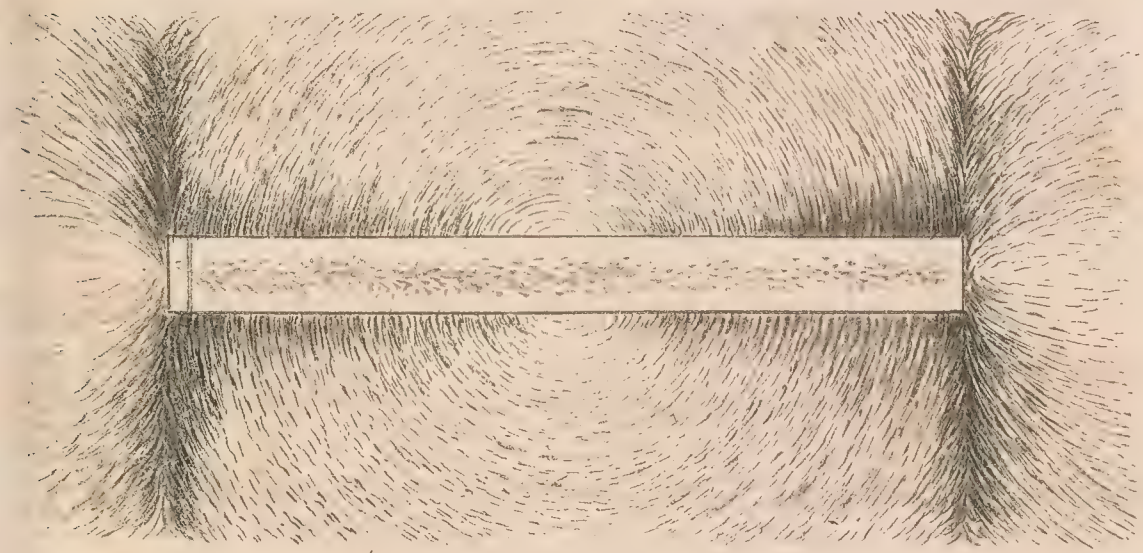
the two magnets, by drawing them
asunder along the surface of the
bar, & continue to separate them
till their ends are at a considerable
distance from its ends. Join them
again, without altering the si-
-tuation of their poles, by a circular
motion of the hands, so that they
may meet at some distance above
the center of the bar, & lay them
again upon it as before. Repeat
this operation on both sides of the
bar till it has acquired a suf-
-ficient degree of magnetism.
The maximum is generally obtain-
-ed after 12 or 14 strokes.
As to the cause of these phenomena
of magnetism which have now
been enumerated nothing has
proved more difficult of investi-

-gation; & notwithstanding they have been known to philosophers for so many years, no very satisfactory solution of them has ever yet been given.

The hypothesis generally received to account for the attraction of the magnet is as follows. A fluid, sui generis is supposed to exist in all ferruginous matter, but that this is stagnant till the action of a magnet has forced it into motion, that when thus put into motion, in any piece of iron, it circulates thro' it & round it in concentric circles flowing always one way.

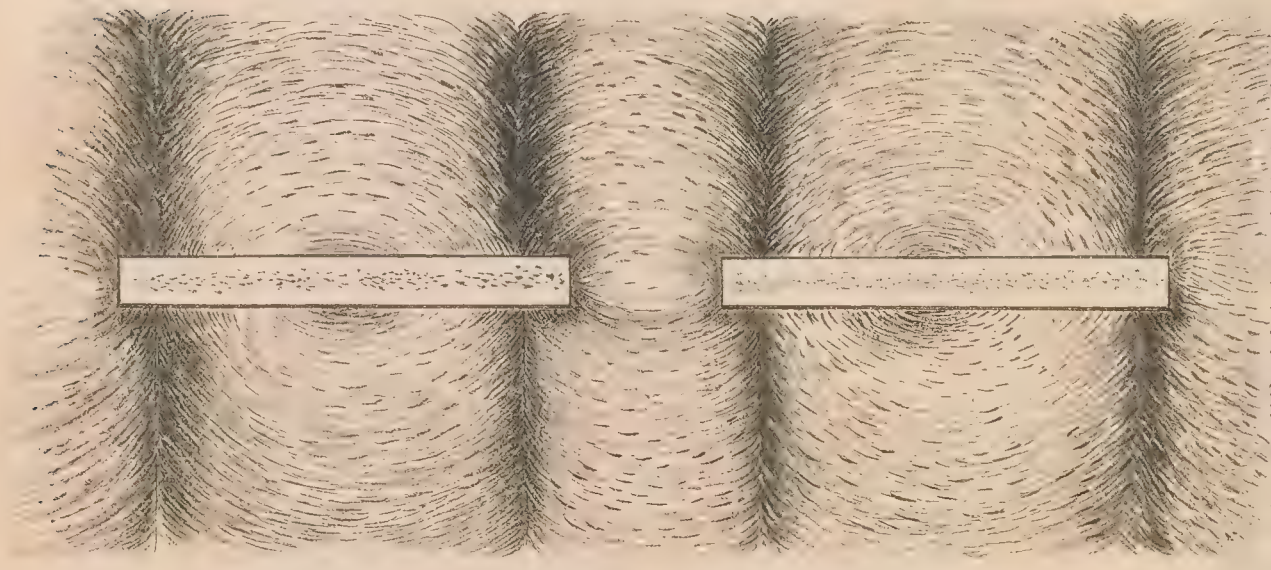
The certainty of this circulation & the nature of it are shewn by placing a magnet under a plate of glass & strewing steel filings on the glass. The filings are by the

action of the magnet thus will be to the circles above mentioned.
The following sketch will shew its appearance



Now when that end of the magnet, from which the fluid is issuing approaches the pole of a contrary name of another magnet, this fluid, rather than circulate round to the other end of its own magnet will enter the extremity of the other, along with the fluid of that magnet there entering & having gone some way, it will emerge from its sides & return in con-

centric circles to the other magnet, so that the ends of the two magnets are involved in a vortex, by the action of which they are strongly impelled towards each other. This may be shewn by placing two magnets in the situation supposed & strewing iron filings on a plate of glass put upon them. The appearance is as here represented



Where the end of a magnet from which fluid is issuing, approaches

a piece of iron not magnetic, it forces its way into its extremity & forming concentric circles such as have been represented, attracts it with consider-able force.

The attraction of the other end of the magnet is accounted for by supposing some of the larger circles returning from the discharging end, to fall upon the parts about the extremity of the presented iron & force a passage thro' it & thus by the formation of a vortex to produce the attraction which takes place.

With regard to the mutual repulsions of the poles of the same name in two magnets, where they are both discharg-ing the fluid, the fluid of each strikes upon the other with force, but can-not enter, for it is supposed that

the pores are now so situated by the first movement of the fluid as only to permit it to pass one way. This force then, together with an accumulation of the fluid occasions a mutual repulsion.

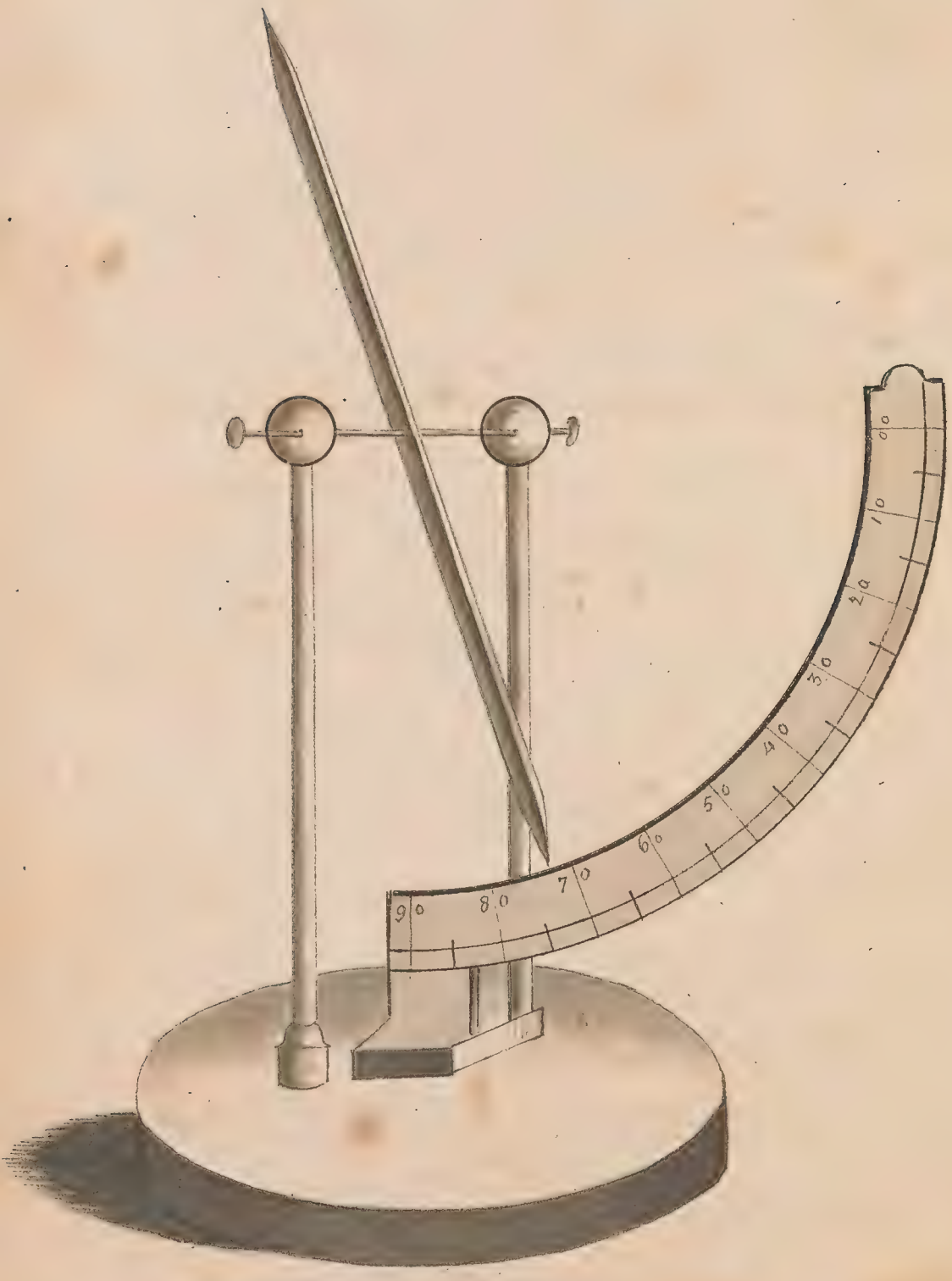
. The filings as before will explain & confirm this idea.

. The direction of the magnetic needle to the poles of the earth is generally accounted for by supposing the earth to be a large magnet, the poles of which nearly coincide with the poles of the earth.

. And the dip of the needle is explained by the supposition that the magnetic poles of the earth lie at some considerable distance from the surface of the earth in the polar regions. The dip of the needle here is such as to make with the plane

of the horizon an angle of more than 70°. In proceeding further north the dip increases, where you approach the polar regions it stands perpendicular, in going south, the angle is less & less, in the equatorial parts the needle is in the plane of the horizon, in southern latitudes, the south pole dips & with a greater & greater angle till in the south polar regions it becomes perpendicular. All this may be satisfactorily imitated by sliding a small dipping needle along a large magnetic bar.

The annexed figure will give an idea of the construction of the dipping needle, observing that the circular limb is a quadrant, & graduated. For sea service, there is a considerable apparatus to keep the axis in a vertical steady.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The quantity of the diſt. not only varies in
different places, but in the same place.
It was in London in 1576. 71°. 30,' in
1720, 75°. 10'. A diurnal variation is also
observable in the quantity of the diſt,
but the mean diſt in London 1776
was 72°. 30"

The directive power of the magnet, or its
property of pointing always to the poles
of the earth, has been turned to the
greatest advantage in Navigation.
Previous to the discovery of this property,
or of its application to this purpose,
navigation was extremely confined.
For the sailor, when he had lost sight
of land, had nothing to assist him in
directing his course but a view of the
heavenly bodies, & as the heavens are
so frequently obscured, this was an
assistance he could not trust to.
But now by the pointing of the
needle he has a director which never

sails home, & by the aid of which he knows at all times the direction of the port to which he wishes to go. With this assistance he is able to make his way over the widest oceans & to traverse the whole globe. To serve this very important purpose in the most convenient manner, a circular card is fastened upon the needle, so as to move about with it. The circular edge of this card is divided into thirty two points, equally distant from each other. Before that point which lies on the north side of the needle, the fleur de lis is drawn, the point of the north is South, that to the East at the distance of 90° is the East point, & that one to the West at the distance of 90° is the West point. From

these cardinal points the intermediate ones take their names.

This instrument is called the Mariners Compass, & the following figure will convey a full idea of it.

Sometime after the application of the needle to the purposes of navigation

tions (which was in the 16 or 17 century) it was discovered, that the needle does not point exactly north, & by observations made in different places, & continued from period to period, it is now found that the direction of the needle differs in almost every place, & that in the same place it differs considerably in a course of years.

Thus the variation of the needle from due north was found to be at London in the year 1576, 11°. 15'. east; in 1657 it was nothing; in 1692. 6° west; in 1776. 21°. 47". west. So that in any one place the variations have a kind of libratory motion, traversing thro' the north to unknown limits Eastward & westward, & it has been observed that the advance in the angle of the variation in given times is not quite

regular: the variation from which is called the variations of the variation.
There is also a diurnal variation of the needle. From 9 in the morning till 2 in the afternoon the needle goes a little to the west, it is there stationary, & then veers to the East, & comes during the night to its former station.
Mr Canton has made some experiments to shew that this is occasioned by the heat of the sun.
The variation of the needle (as has been said) differs at the same time in different places.
In the north Atlantic & Eastward Dale over the Indian Ocean, except in the Bay of Bengal, there is a westerly variation, but to the westward of a certain line, at which there is no variation, all along the coast of South

America, & in the Pacific Ocean as far at the 140 degree of west longitude, an easterly variation is observed.

This great diversity in the variations, in different places, shews the greatness of a chart of variations. But since the variation at the same place is continually changing, a frequent renewal of such charts must be necessary.

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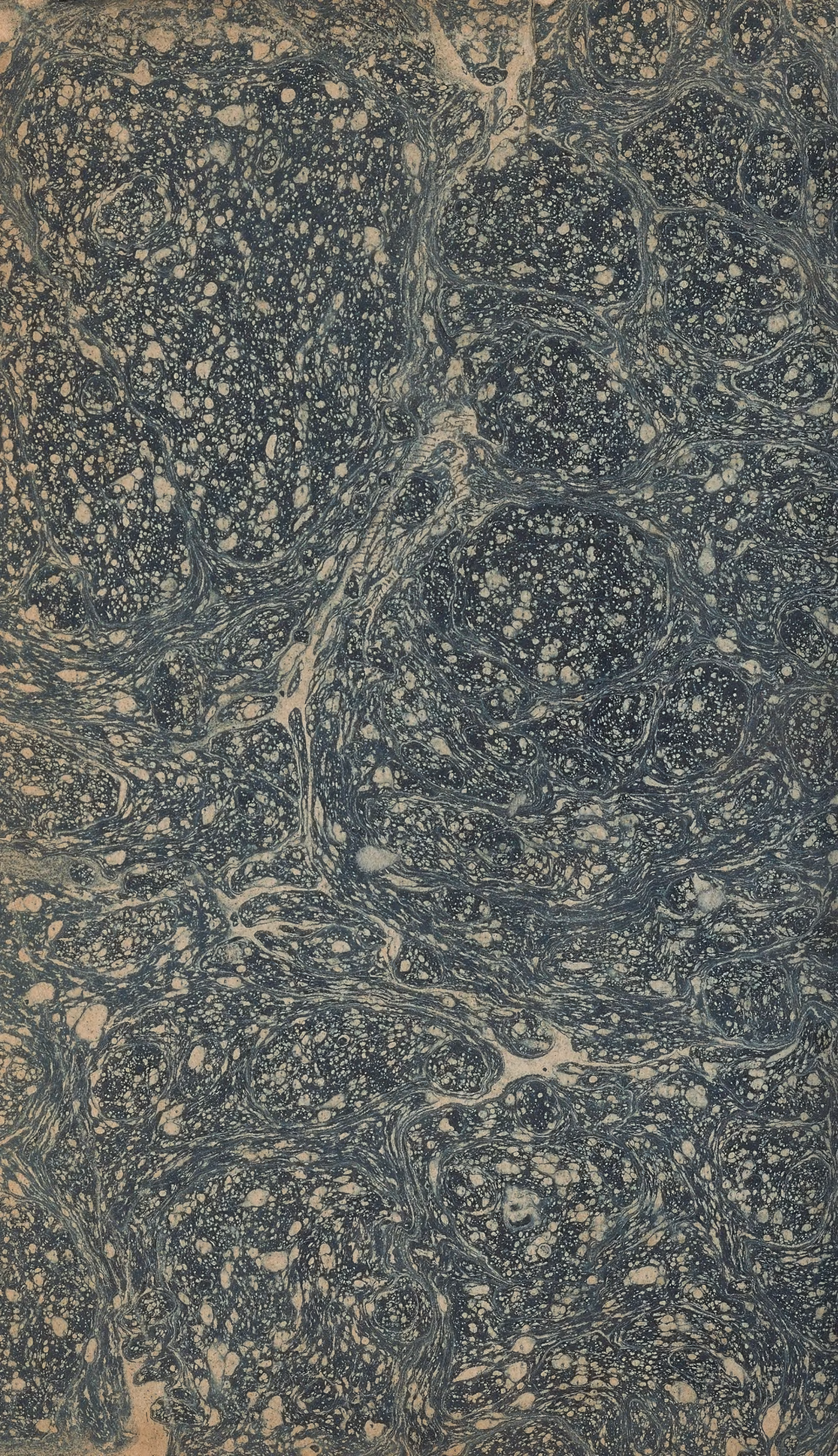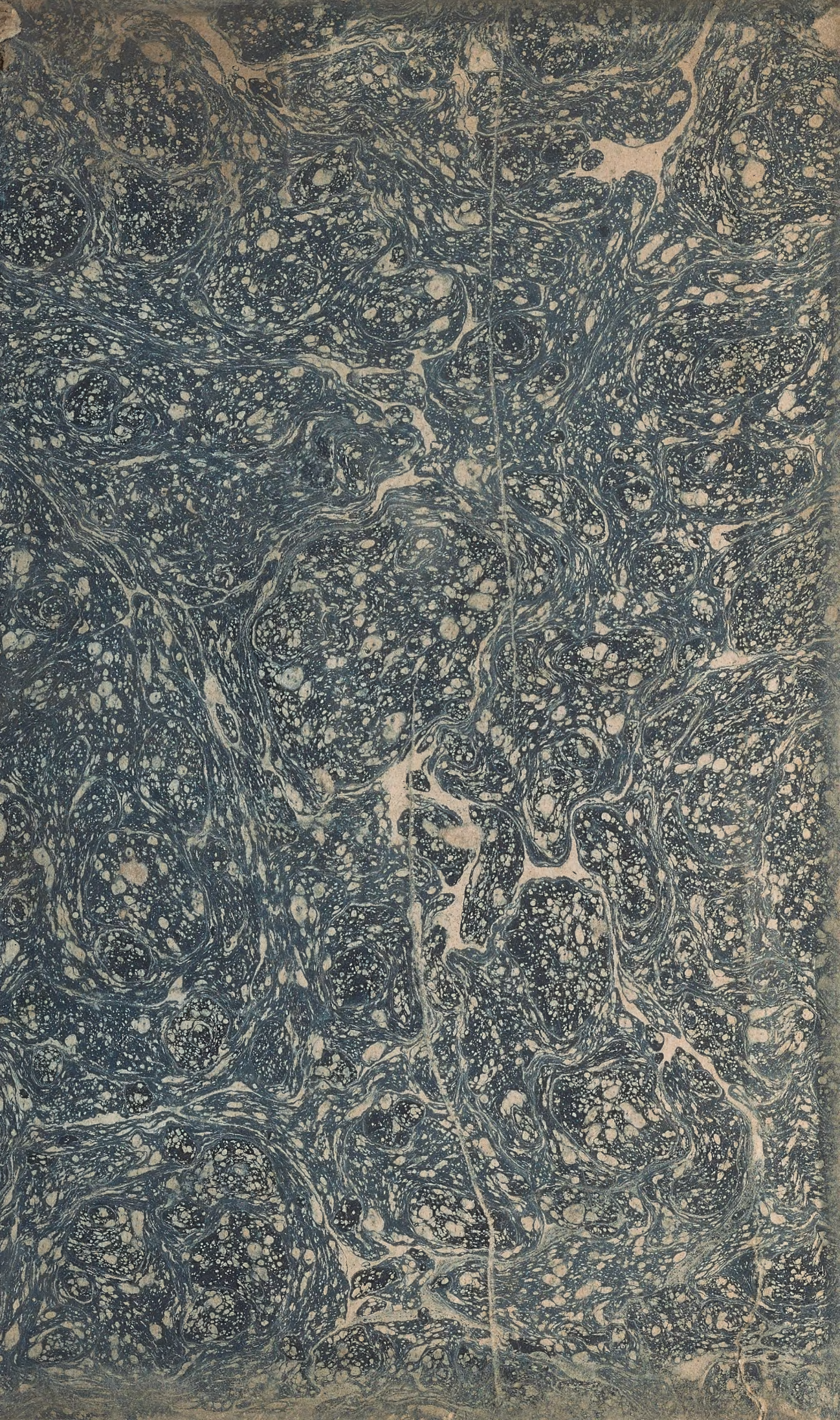
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